

Influences of precipitation and temperature trend on maize yields

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Abstract

Maize yield for three decade period of the last century (1961-1990) were in Hungary for 15% higher than in Croatia (means 3.81 and 4.39 t/ha, respectively) and this trend was continued in the 1996-2007 period. However, amplitude of maize yields (differences among year (for the 1996-2007) in Hungary were higher (from 3.60 to 7.56 t/ha) than in Croatia (from 3.86 to 6.92 t/ha). Aim of this study was testing maize yield, precipitation and air-temperature variations in four Counties (Croatia: Vukovarsko-Srijemska =VSC and Virovitičko-Podravska =VPC; Hungary: Békés = BC and Fejér =FC). Mean yield in VSC for 1996-2007 period was for 16% higher than in VPC. Yields in three less favorable years (LFY: 2000, 2003 and 2007) were considerably lower (means 5.22 and 4.41 t/ha, for VSC and VPC, respectively) than in three more favorable years (MFY: 1997, 2002 and 2005) years (means 7.50 and 7.00, respectively). Precipitation (means of two sites: Osijek and Virovitica) in 3-months period June-August was in LFY for 58% lower than in MFY (129 mm and 305 mm, respectively). At the same time, air-temperatures were for 2.0°C higher (22.7 and 20.7°C, respectively). Mean yield in BC for 1996-2007 period was for 21% higher than in FC. Yields in three LSY were considerably lower (means 3.78 and 3.79 t/ha, for BC and FC, respectively) than in three MFY (means 6.13 and 7.30 t/ha, respectively). Precipitation (means of two sites: Békéscsaba and Székesfehérvár) in 3-months period June-August was in LFY for 51% lower (115 mm and 235 mm, respectively) and air-temperatures were for 1.9°C higher (22.1 and 20.2°C, respectively) than in MFY. Precipitation and temperature trends for LFY and MFY in two sites of both countries were similar with emphasis that in Hungary they were negligible lower.

Key words: maize, precipitation, temperature, yield, Croatia, Hungary

Introduction

Maize yields under Central and Eastern European conditions are under considerable influences of weather characteristics, especially precipitation and temperature regimes, during growing season. Shortage of precipitation and higher air-temperatures are mainly in connection with lower maize yields (Josipovic et al., 2005; Kovacevic et al., 2007). Global climate change is one of the major issues today. There is a continuous rise in temperature followed by the increasing frequency of weather anomalies (Lang et al., 2006). In Hungary, ascending levels of temperature rise, with a magnitude of 1°C, and decreasing trend-line of annual precipitation during one century for 83 mm can be observed (Jolankai et al., 2006). For this reason, global climatic changes correspondingly reflected on field crop yields. The aim of this study was to evaluate maize yield and weather (month precipitation and mean air-temperature in the period 1966-2007) variations in total four counties situated in Hungary and Croatia.

Material and methods

The data of State Bureau for Statistics (Statistical Yearbooks) were used as source of maize yield data for Vukovarsko-Srijemska (VSC) and Virovitičko-Podravska (VPC) Counties

(Croatia), Békés (BC) and Fejér (FC) Counties (Hungary). State Hydrometeorological Institutes (Zagreb and Budapest) were the sources of meteorological data for Osijek, Virovitica (Croatia), Békéscsaba and Székesfehérvár (Hungary).

VSC (2448 km²) and VPC (2021 km²) are participating with 7.9% in total territory of Croatia. However, their contribution in arable land capacities (harvested area only) of the country is 24.2% (status 2006: 207724 ha and 856249 ha, respectively) and in maize harvested area 17.3% (51210 ha and 296251 ha, respectively). In general, VSC had more fertile soils (prevailing soil type: eutric cambisol) in comparison with VPC (prevailing soil type: stagnic albeluvisol), as reported by Janekovic (1971). Annual precipitation in northern Croatia have increasing trend in EW direction (1961-1990: Osijek = 650 mm, Varazdin = 879 mm), while temperatures have decreasing trend (10.8°C and 9.9°C, respectively).

FC has a total territory of 4373 km², representing 4.7 %, while BC with its 5631 km² is representing 6.05 of the total area of Hungary (93030 km²). Both Counties belong to the Great Plain – FC is located in Transdanubia, while BC is located east of the Tisza river. Soil type of both Counties is mainly of chernozem type, however in FC there are some meadow soils and forest soils, too. In BC apart from chernozems there are some floodplain soils (fluvisols) as well, with a minor area of salt affected soils. The annual mean temperature is 11°C for the Hungarian Great Plain, with a forecasted 2-2.5°C warming (European Commission DG Environment, Brussels, 2008).

Results and discussion

Maize harvested area in Croatia in the period 1996-2005 had been decreased in comparison with 1960-1989 period (means 509068 ha and 344663 ha, respectively). However, in Hungary it was relative constant and twofold higher (means 1192887 ha and 1143794 ha, for the period 1961-1990 and 1996-2005, respectively).

Maize yield for three decade period of the last century (1961-1990) were in Hungary for 15% higher than in Croatia (means 3.81 and 4.39 t/ha, respectively), and this trend was continued (Table 1). However, amplitude of maize yields (for the 1996-2007) in Hungary were higher (from 3.60 to 7.56 t/ha) than in Croatia (from 3.86 to 6.92 t/ha), probably due to stronger effects of drought stress in Hungary (Table 2 and 3).

Kovacevic et al. (1994) showed results of maize production in Croatia in the 1960-1989 period. Mean harvested area of maize was 509068 ha/year. Mean grain yield was 3.81 t/ha and variation of annual yields was from 2.45 to 5.33 t/ha. Maize yield in Vukovar municipality (now part of VSC) was 6.00 t/ha (annual yield variation from 3.14 to 8.43 t/ha), while in Podravska Slatina municipality (now Slatina and part of VPC) it was 4.13 t/ha or 31% lower (from 2.94 t/ha to 5.81 t/ha). Precipitation in the period May-August (1960-1989) was 214 mm and 249 mm, for Osijek and Podravska Slatina, respectively.

In our study, mean maize yields for the 1969-2005 were 6.73 and 5.94 t/ha, for VSC and VPC, respectively. In general, maize yields are higher than in 1960-1989 period and yield differences between two areas are lower: only 12% lower yield in VPC in comparison with VSC (Tab. 2). Possible explanation could be investment in soil reclamation.

Mean yields in VSC for 1996-2007 period was for 16% higher than in VPC. Yields in three less favorable years (LSY: 2000, 2003 and 2007) were considerably lower (means 5.22 and 4.41 t/ha, for VSC and VPC, respectively) than in three more favorable (MFY: 1997, 2002 and 2005) years (means 7.50 and 7.00, respectively). Precipitation (means Osijek and Virovitica) in 3-months period June-August was in LFY for 58% lower than in MFY (129 mm and 305 mm, respectively). At the same time, air-temperatures were for 2.0°C higher (22.7 and 20.7°C, respectively).

Table 1. Harvested areas and yields of maize in Croatia and Hungary

Maize harvested areas (ha) and yields (t/ha): VSC (Vukovarsko-srijemska), VPC (Virovitičko-Podravska), Békés (Békés megye) and Fejér (Fejér megye) Counties

Year	Croatia				Hungary			
	Croatia		Harvested (ha)		Hungary		Harvested (ha)	
	ha	t/ha	VSC	VPC	ha	t/ha	Békés	Fejér
	1960-69 (a), 1970-79 (b), 1980-89 (c) periods (Kovacevic et al., 1994)				1961-70 (a), 1971-80 (b), 1981-90 (c) periods (Nagy-Sárvári, 2005)			
<i>a</i>	520050	2.90			1223000	3.02		
<i>b</i>	500580	3.85			1294000	4.40		
<i>c</i>	506575	4.68			1061660	5.74		
	The period 1965-2007				The period 1965-2007			
1996	361268	5.22	26888	32537	1105342	5.45	109428	77373
1997	371273	5.88	27508	32709	1108211	6.22	109712	77575
1998	374531	5.27	43170	26135	987346	5.87	97747	69114
1999	384184	5.56	46411	27362	1078544	6.58	106776	75498
2000	388639	3.93	48525	26769	1181813	4.15	116932	83561
2001	405910	5.45	52633	28102	1238816	6.22	120610	80632
2002	407272	6.14	48681	28797	1200535	5.05	127482	74273
2003	405947	3.86	44646	31859	1149649	3.94	94650	79484
2004	-	-	-	-	1190141	7.00	95672	78976
2005	318891	6.92	32670	27884	1197547	7.56	98300	84003
<i>Mean</i>	344663	5.36	41237	29128	1143794	5.80	107731	78049
2006	296251	6.53	26990	24220	1229153	6.87	103830	88760
2007	288549	4.94			1119044	3.60	100693	77837

Table 2. Maize yield and meteorological data variations for 1996-2007 period in Croatia

Maize yield (t/ha) in Vukovarsko-srijemska (VSC) and Virovitičko-podravska (VPC) Counties and meteorological data for Osijek and Virovitica

Year	Maize		Precipitation (mm) and mean air-temperatures (°C)											
	yield		Osijek						Virovitica					
	(t/ha)		June		July		August		June		July		August	
	VSC	VP C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C
1996	7.06	5.84	30	21.1	95	19.9	77	20.6	26	20.6	59	19.7	74	20.0
1997	7.29	6.83	86	20.8	91	20.3	41	20.5	107	20.5	112	20.5	61	20.6
1998	6.49	5.88	26	21.4	84	22.2	99	21.8	100	21.2	173	21.6	137	21.0
1999	7.29	5.82	150	20.3	95	21.9	74	21.3	158	19.8	136	21.8	83	20.9
2000	4.72	4.30	10	22.5	63	21.7	5	23.7	41	21.6	73	21.1	3	22.7
2001	7.37	5.94	240	18.1	77	21.6	7	22.7	128	18.3	81	21.8	15	22.1
2002	6.82	7.67	36	21.1	59	22.3	77	20.9	53	21.6	90	22.4	92	20.8
2003	5.15	4.57	44	24.3	61	22.1	41	23.6	81	23.9	48	22.8	24	24.4
2004	-	-	77	19.2	43	21.5	96	21.0	114	19.4	42	21.3	40	21.0
2005	8.38	6.50	112	19.5	171	21.5	238	19.3	59	19.7	165	21.3	178	18.9
<i>x</i>	6.73	5.94	81	20.8	84	21.5	76	21.5	87	20.7	98	21.4	71	21.2
2006	7.44	5.63	91	20.1	15	23.5	134	19.3	73	20.2	27	23.3	147	19.2
2007	5.80	4.40	33	22.3	27	23.9	45	22.2	79	21.6	20	22.3	76	21.1
			Means 1961-1990						Means 1971-1990					
			88	19.5	65	21.1	58	20.3	87	18.3	76	20.3	75	19.6

Table 3. Maize yield and meteorological data variations for 1996-2007 period in Hungary

Maize yield (t/ha) in Békés and Fejér Counties and meteorological data for Békéscsaba and Székesfehérvár

Year	Maize grain		Precipitation (mm) and mean air-temperatures (°C)											
	yield		Békéscsaba						Székesfehérvár					
	t/ha		June		July		August		June		July		August	
	Bekes	Fejér	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C
1996	6.18	6.21	62	20.0	60	19.0	148	20.2	59	19.7	77	-	136	20.0
1997	6.30	6.71	78	19.5	127	19.5	58	19.7	60	19.5	74	19.7	18	21.0
1998	6.14	6.50	45	20.5	84	21.0	55	21.0	76	20.2	80	21.2	56	21.0
1999	6.45	7.15	81	20.0	74	22.0	63	20.0	115	19.0	118	21.8	57	20.0
2000	3.80	4.50	11	21.0	47	21.0	2	23.4	7	20.1	59	19.3	9	22.4
2001	6.81	7.10	164	18.1	64	21.3	40	22.1	35	17.0	36	20.7	26	21.8
2002	4.91	6.17	47	21.2	75	23.3	34	21.6	22	20.3	66	21.9	146	20.0
2003	3.31	4.14	17	22.7	34	22.4	10	24.1	16	22.4	65	21.1	46	23.7
2004	6.75	7.44	89	19.7	109	21.8	80	20.9	138	17.6	33	19.8	28	20.2
2005	7.17	9.01	44	19.1	89	21.4	152	19.8	40	18.2	76	20.2	200	18.2
x	5.18	6.50	64	20.2	76	21.3	64	21.3	57	19.4	68	20.6	72	20.8
2006	6.50	8.18	76	19.4	41	23.3	115	19.9	142	18.6	21	22.8	91	17.8
2007	4.24	2.74	76	22.5	37	23.8	60	22.9	37	21.0	28	22.6	127	20.7
			Means 1961-1990						Means 1961-1990					
			74	19.3	57	21.4	46	20.8	64	18.3	54	20.3	48	19.5

Difference of precipitation amounts between 1961-1990 (Kovacevic et al.,1994) and 1996-2007 periods in eastern Croatia was low (225 mm and 240 mm, respectively) while air-temperature in the recent period was for 1.4°C higher (19.9°C and 21.3°C, respectively). However, amplitude of precipitation quantities in the recent 1996-2007 period was higher, mainly due to extremely drought stress (Table 2).

Mean yields in BC for 1996-2007 period was for 21% higher than in FC. As in Croatia, yields in three LSY (2000, 2003 and 2007) were considerably lower (means 3.78 and 3.79 t/ha, for BC and FC, respectively) than in three MFY (1997, 2002 and 2005) (means 6.13 and 7.30 t/ha, respectively). Precipitation (means Békéscsaba and Székesfehérvár) in the period June-August was in LFY for 51% lower than in MFY (115 mm and 235 mm, respectively). At the same time, air-temperatures were for 1.9°C higher (22.1 and 20.2°C, respectively). Precipitation and temperature trends for LFY and MFY in two sites of both countries were similar with emphasis that in Hungary they were negligible lower.

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